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Patentanmeldung Nr. Patent application No. Demande de brevet n°

02077911.2

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Der Präsident des Europäischen Patentamts;
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For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Forge welding method

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FORGE WELDING METHOD

Background of the invention

The invention relates to a method for joining pipe ends by forge welding.

Forge welding involves circumferential heating of the pipe ends that are to be joined and subsequently pressing the pipe ends together to form a metallurgical bond.

A large variety of heating technologies may be used to make the pipe ends hot enough such that the metallurgical bond can be made. The heating techniques may involve electric, electromagnetic, induction, infrared, sparking and/or friction heating or combinations of these and other heating methods.

When used in this specification the term forge welding is intended to encompass all techniques which involve circumferential heating of pipe ends and subsequent metallurgical bonding the heated pipe ends, including welding techniques that are generally known as amorphous bonding, diffusion bonding, friction welding, flash butt welding and/or thermodynamic welding.

It is known from US patents 4,566,625 ; 4,736,084 ; 4,669,650 and 5,721,413 issued to Per H. Moe that it may be beneficial to flush the pipe ends just before and during the forge welding operation with a reducing flushing gas, such as hydrogen or carbon monoxide, such that any oxygen skin is removed from the heated pipe ends and a metallurgical bond with a minimal amount of irregularities is obtained. It is also known from US patents 2,719,207 and 4,728,760 to use

non explosive mixtures comprising about 95% by volume of a substantially insert gas, such as argon, nitrogen and/or helium, and about 5% by volume of a reducing gas, such as hydrogen and/or carbon monoxide for flash welding and induction butt welding.

Experiments have shown that forge welding techniques are capable to generate high quality metallurgical bonds between tubular ends, in particular if the pipe ends are flushed with a reducing flush gas mixture during the heating and/or welding operation, but that the red-hot pipe ends are generally deformed such that upsets are formed in the region of the welding zone.

For many applications it is required to remove upsets after the welding operation, which then involves a grinding or machining operation which is difficult and expensive to accomplish at many sites where pipe ends are welded together, such as on oil rigs, pipe-laying barges and many offshore and onshore sites where underground or above ground pipelines are to be installed.

It is an object of the present invention to provide a method for forge welding of tubulars wherein the generation of upsets in the welding zone is minimized.

Summary of the Invention

The method according to the inventions comprises shaping at least one of the inner and outer walls of the tubular ends that are to be welded together into an inwardly sloping configuration such that when the tubular ends are heated during the forge welding process the heated tubular ends deform as a result of thermal expansion into a substantially longitudinally oriented cylindrical shape. In addition the portion of each pipe that is to be forged may be reduced in cross section such

that deformation during forging returns it to a dimension substantially the same as its original thickness.

The precise angles and dimensions of the end preparation depend on the material being joined and its coefficient(s) of expansion, wall thickness, pipe diameter, degree of heat required for welding, the width of the heated zone and the desired forge length. Typical values are provided in Table 1 below for carbon steel tubes approximately 4 mm wall thickness and 70 mm diameter.

The sloping angle of the inner and/or outer walls of the tubular ends may be selected such that the ratio between the average diameter D(t) of the tip of the tubular end and the average diameter D(b) of the base of the tubular end is related to an estimated temperature difference between said tip and base of the tubular end during the forge welding process and a thermal expansion co-efficient of the steel grade(s) of the tubular end.

For many forge welding operations said ratio D(t)/D(b) may be selected between 0.8 and 0.99.

To increase the surface of the forge welded pipe ends and to simultaneously assist alignment of the pipe ends the end face of one of the tubular ends that are to be welded together may a substantially convex shape and the end face of the other tubular end may have a substantially concave shape.

The forge welded tubulars may comprise a low grade steel base pipe and a higher grade steel cladding on the inner and/or outer surface of the base pipe. In such case it is preferred that the end faces are shaped such that when the tubular ends are pressed together the end faces of the cladding(s) touch each other first the end faces of the base pipe ends subsequently touch each other.

It is also preferred that any non-oxidising or reducing flush gas is introduced from the opposite side of the pipe wall to the clad layer.

It will be understood that the inwardly tapered tubular end may have a large variety of shapes, and that the inward deflection may be determined by iterative calculation and/or experiments in order to asses that the amount of upset of the forge welded tubulars is reduced to a minimum.

In use the amount of material at the pipe ends deformed by forging is closely controlled to further minimise upset.

It is observed that US patent 4.669.650 discloses a forge welding process wherein the outer walls of the tubular ends are machined away to a greater depth that the inner walls of the tubular ends. The known configuration is, however, not configured such that t he heated tubular ends are substantially cylindrical during the forge welding operation.

Description of a preferred embodiment

A preferred embodiment of the method according to the present invention will be described with reference to the accompanying Fig.1 and 2, in which X is the inward sloping angle, 1 = original wall thickness, 2 = minimum forge length required to complete the weld, 3,5,6 = typical radii, 4 = first contact shoulder, 7 = reduced wall thickness and 8 = pipe center line.

An outline of the dimensions of the pipe connection shown in Fig. 1 and 2 is outlined in Table 1:

Identifier (see Figure 1)	Description	Typical Value
X	Inward sloping angle	1 to 5°.
1	Original wall thickness	4 mm
3, 5, 6	Preparation radii	0.6 mm
2	Minimum forge length	0.05 mm
7	Reduced wall thickness	3 mm
8	Pipe centre line	
4	First contact shoulder	

Table 1: Typical critical values for forge welding weld preparation - 4mm WT, 70 mm OD pipe

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C L A I M S

1. A method for interconnecting tubulars by forge welding, the method comprising shaping at least one of the inner and outer walls of the tubular ends that are to be welded together into an inwardly sloping configuration such that when the tubular ends are heated during the forge welding process the heated tubular ends deform as a result of thermal expansion into a substantially longitudinally oriented cylindrical shape.

2. The method of claim 1, wherein the sloping angle of the inner and outer walls of the tubular ends is selected such that the ratio between the average diameter D(t) of the tip of the tubular end and the average diameter D(b) of the base of the tubular end is related to an estimated temperature difference between said tip and base of the tubular end during the forge welding process and a thermal expansion co-efficient of the steel grade or grades of the tubular end.

3. The method of claim 2, wherein said ratio D(t)/D(b) is between 0.8 and 0.99.

4. The method of claim 1, wherein the end face of one of the tubular ends that are to be welded together has a substantially convex shape and the end face of the other tubular end has a substantially concave shape.

5. The method of claim 4, wherein tubulars comprise a low grade steel base pipe and a higher grade steel cladding on the inner and/or outer surface of the base pipe and the end faces are shaped such that when the tubular ends are pressed together the end faces of the

cladding(s) touch each other first the end faces of the base pipe ends subsequently touch each other.

6. The method of claim 1, wherein the tubular ends are machined to a reduced wall thickness in the welding zone.

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A B S T R A C T

FORGE WELDING METHOD

A method for forge welding tubulars such that formation of upsets in the welding zone is minimized comprises shaping the tubular ends that are to be welded together into an inwardly sloping configuration such that when the tubular ends are heated during the forge welding process the heated tubular ends deform as a result of thermal expansion into a substantially longitudinally oriented cylindrical shape.

(Fig.1)

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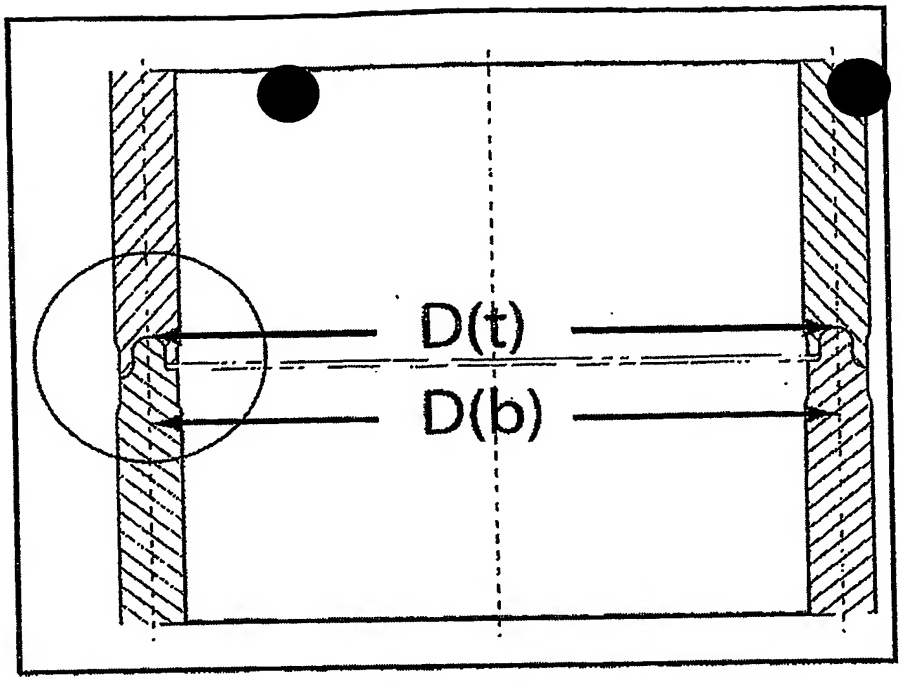

Figure 1

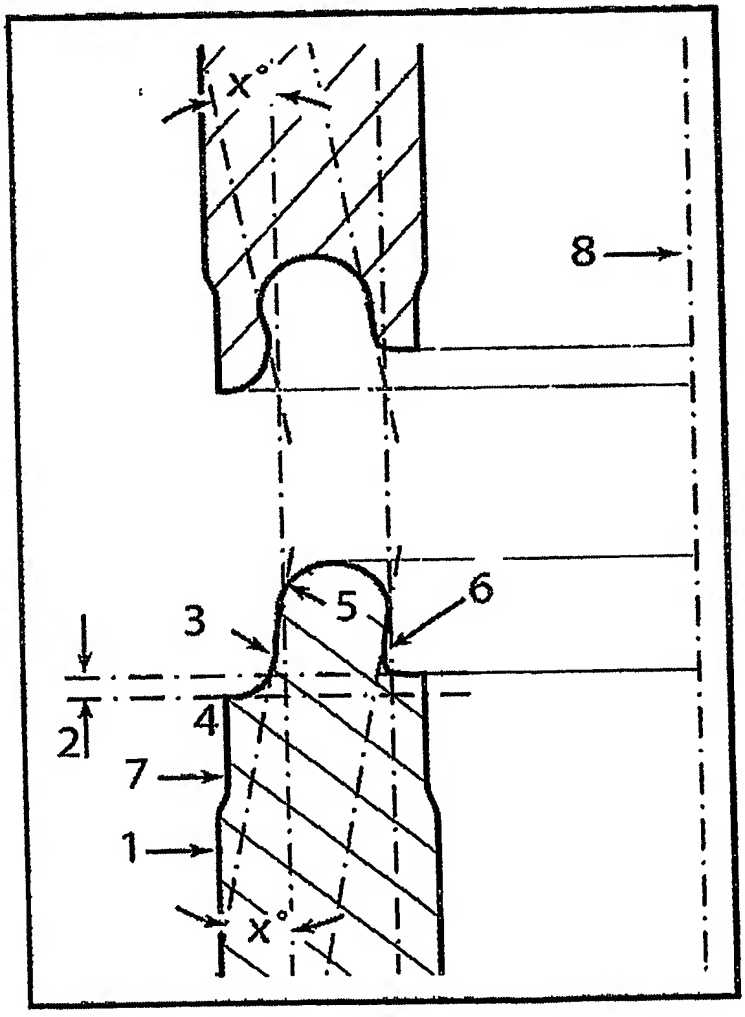

Figure 2

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